

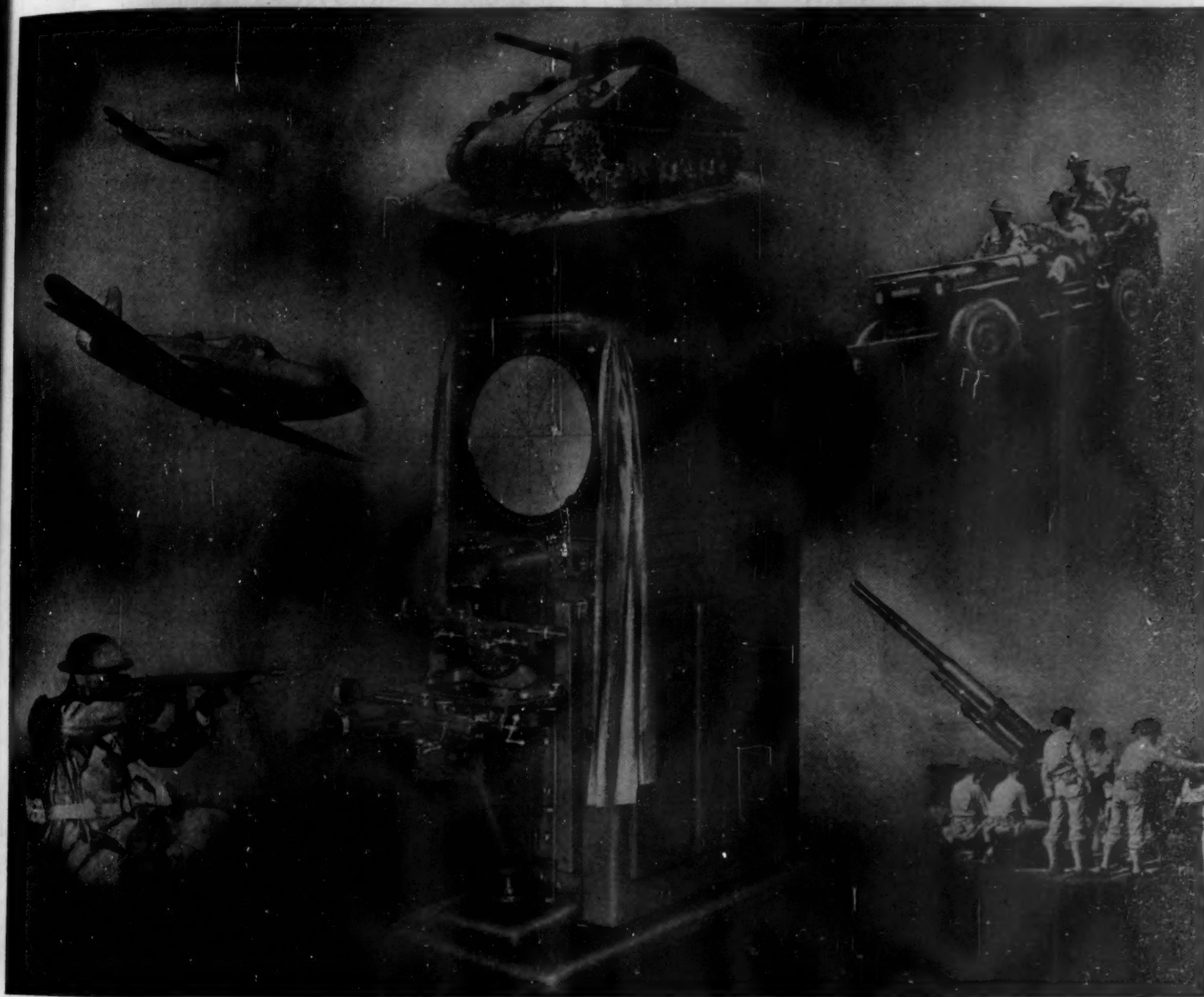
SEP 20 1943

SCIENCE

NEW SERIES
VOL. 98, No. 2542

FRIDAY, SEPTEMBER 17, 1943

SUBSCRIPTION, \$6.00
SINGLE COPIES, .15



Bausch & Lomb Contour Measuring Projector

Today Precision *Must* Be Commonplace



American fighting men on our fighting fronts depend upon production line accuracy... for ten-thousandths of an inch variation on the production line can mean the difference between a hit or a miss on the battleline.

The Bausch & Lomb Contour Measuring Projector makes such accuracy possible on the fastest moving production lines, because it takes many vital inspection jobs "off the surface plate" and eliminates the tedious, time-consuming computations of the "sine bar." Inspections for accuracy become routine jobs.

Throwing an accurate, sharply defined shadow image of the object under examination on a translucent

screen, the B&L Contour Projector permits exact measurements or comparison with an enlarged template drawing at magnifications great enough for easy and accurate dimensioning.

Here again is a Bausch & Lomb peacetime development that serves America at War. The B&L Contour Measuring Projector is helping speed production of fighting tools for our fighting men.

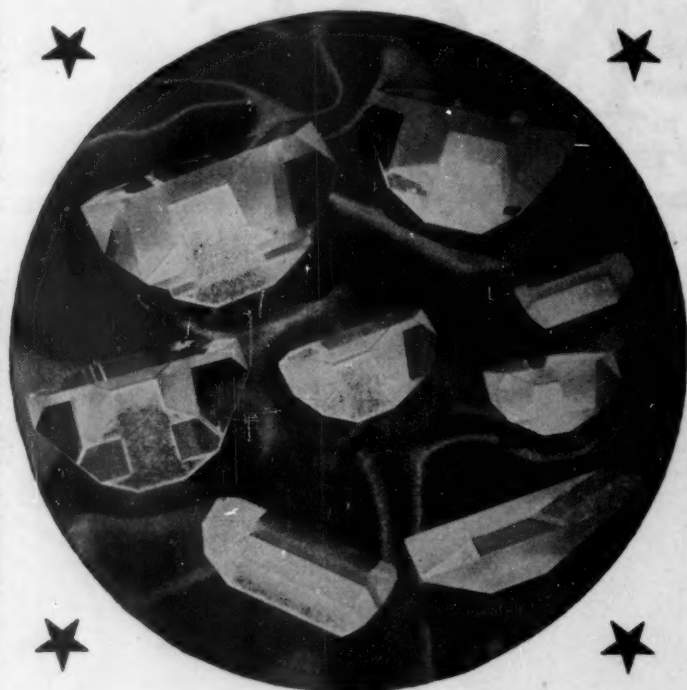
For Bausch & Lomb Instruments essential to Victory—priorities govern delivery schedules.

BAUSCH & LOMB
OPTICAL CO. • ROCHESTER, NEW YORK
ESTABLISHED 1853

AN AMERICAN SCIENTIFIC INSTITUTION PRODUCING OPTICAL GLASS AND INSTRUMENTS FOR MILITARY USE, EDUCATION, RESEARCH, INDUSTRY AND EYESIGHT CORRECTION

Science: published weekly by The Science Press, Lancaster, Pa.

Entered as second-class matter July 18, 1923, at the Post Office at Lancaster, Pa., under the Act of March 3, 1879.



Military Requirements

demand roof prisms in quantity and wide variety.

Perkin-Elmer Corporation developed the method for producing these most accurate of all manufactured parts in quantity. It also furnishes more types of this prism than any other manufacturer in the United States.





THE PERKIN-ELMER CORPORATION
GLENBROOK • CONN.

Manufacturers of...

PRECISION LENSES • PRISMS and MIRRORS
★ OPTICAL DESIGN AND CONSULTATION ★

PHYSICIST WANTED—Leading manufacturer of industrial radio frequency equipment desires the services of a physicist or electrical engineer to direct developmental and applications laboratory. This field is expanding rapidly and offers excellent opportunities for advancement. Position of a permanent nature. Present activities devoted entirely to the War effort. Address replies to

A.B.C. Science, Lancaster, Pennsylvania

MATHEMATICS DICTIONARY

By Prof. Glenn James of the Univ. of Calif. and R. C. James of Cal-Tech. Provides standard definitions of the terms and phrases from arithmetic through elementary differential equations, and more advanced basic terms. Includes easy examples, many illustrations and formulas, and extensive tables.

One reader has called it "Ten texts in one." The *Professional Engineer*: "At last a reference book which really provides mathematical information. It is perhaps the best book that has been made available to those interested in mathematics for many a day."

Second edition, 1943; flexible or non-flexible binding; 327 pages; \$3.00.

THE DIGEST PRESS, Dept. 4-B
VAN NUYS CALIFORNIA

For Laboratory and Demonstration:

Hylo #1 Melting Furnace, Crucibles, Assay Scorifiers, Muffles, Tongs, Asbestos Mittens, Annealing Ovens.

Dealer and Manufacturer

ALEXANDER SAUNDERS

95 Bedford Street

New York, N. Y.

LaMotte Pomeroy Sulfide Testing Set

This outfit was developed for the accurate determination of Total Sulfides, Dissolved Sulfides, and Free Hydrogen Sulfide in Air and Gases. The methods of testing employed are those of Dr. Richard Pomeroy, with whose cooperation the apparatus has been developed. Outfit comes complete with necessary reagents, pipettes, glassware and full instructions.

Write for further information

LaMotte Chemical Products Co.
Dept. "H" Towson 4, Baltimore, Md.

SCIENCE

VOL. 98

FRIDAY, SEPTEMBER 17, 1943

No. 2542

Aristotle, Newton, Einstein: PROFESSOR E. T. WHITTAKER 249

Obituary:

Aleš Hrdlička: PROFESSOR WILTON MARION KROGMAN. *Recent Deaths* 254

Scientific Events:

Gifts and Grants to the University of Illinois; Field Museum of Natural History; The Third Nation-Wide Science Talent Search; New and Rare Instruments; Available Teachers of Collegiate Mathematics; The Woods Hole Marine Biological Laboratory 255

Scientific Notes and News 258

Discussion:

The Discovery and Development of Potash in Texas and New Mexico Permian: DR. A. F. WOODS. *"Chemical" Seed Treatments:* PROFESSOR K. STARR CHESTER. *Mineral Deposits:* DR. J. J. WOLFORD 260

Quotations:

The Retirement of Professor Raymond C. Archibald 261

Scientific Books:

The Blood in Tuberculosis: DR. E. M. MEDLAR 262

Special Articles:

An Experimental Test of the Framework Theory of Antigen-Antibody Precipitation: PROFESSOR LINUS PAULING, DR. DAVID PRESSMAN and PROFESSOR DAN H. CAMPBELL. *The Production of Multipolar Mitoses in Normal Embryonic Chick Cells:* DR. E. FRANCES STILWELL. *The Role of Night Temperature in Plant Performance:* PROFESSOR RAY H. ROBERTS 263

Scientific Apparatus and Laboratory Methods:

Microbiological Determination of Amino Acids: DR. K. A. KUIKEN, WILLIAM H. NORMAN, DR. CARL M. LYMAN and FRED HALE 266

Science News 12

SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. McKEEN CATTELL; WARE CATTELL, assistant editor. Published every Friday by

THE SCIENCE PRESS

Lancaster, Pennsylvania

Annual Subscription, \$6.00

Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary in the Smithsonian Institution Building, Washington, D. C.

ARISTOTLE, NEWTON, EINSTEIN¹

By Professor E. T. WHITTAKER, F.R.S.

UNIVERSITY OF EDINBURGH

It falls to us this year to commemorate the greatest of men of science, Isaac Newton, on the occasion of the three-hundredth anniversary of his birth. The centuries have not dimmed his fame, and the passage of time is unlikely ever to displace him from the supreme position. His discoveries, however—and this is part of their glory—have not persisted unchanged, but in the hands of his successors have been continually unfolding into fresh evolutions. During the eighteenth and nineteenth centuries there was an immense expansion of knowledge, springing directly from his work, and forming ultimately a vast superstructure based on the Newtonian concepts of space, mass, and force. Since 1900 the progress of science has continued, but the development of physics has

changed in character: it has become subversive and radical, questioning the traditional assumptions and uprooting the old foundations. In 1915 the Newtonian doctrine of gravitation was superseded by that of Einstein: the divergence between the results of the two theories, so far as concerns the calculation of the movements of the planets, is extremely slight, and indeed, in almost all cases, too small to be detected by observation; but on the question of the essential nature of gravitation, the two conceptions differ completely and are associated with opposite philosophies of the external world. The other great discovery of the present century is the quantum theory, which in its perfected form of quantum-mechanics appeared in 1925: this also is completely irreconcilable with the postulates of Newtonian science.

We have therefore come now to the end of an age—

¹Address of the president of the Royal Society of Edinburgh, October 26, 1942.

the age of classical physics—which we may count as having extended from the publication of Newton's "Principia" in 1687 to the acceptance of general relativity and quantum-mechanics by our own contemporaries—about 250 years. The replacement of the Newtonian fundamental assumptions by a wholly different set of concepts, which is now taking place, represents a change in the philosophical view of the world which future generations will regard probably as one of the major turning-points in the history of thought, and perhaps as the most significant event of our time.

This afternoon I propose to set the revolution of the twentieth century, by which the doctrines of classical physics have been overthrown, side by side with the revolution of the seventeenth century, by which they were originally established. It will appear that in some respects the second movement is reversing the direction of the first, and is bringing back ideas which were accepted in the great days of the Scholastic philosophy, but which, having been discarded at the Renaissance, have for the last three hundred years been unknown outside a small circle of scholars.

I have therefore taken for these remarks the title "Aristotle, Newton, Einstein." "Aristotle" stands for the interpretation of the world which was developed, on the foundation of the Aristotelian physics and metaphysics, by the Scholastic philosophers of the thirteenth century; "Newton" symbolizes classical physics, which displaced Scholasticism and is now in its turn outmoded; and "Einstein" represents the new conceptions which have arisen in connection with quantum-mechanics and general relativity and on which the physics of the future must be based.

Let us, then, first inquire what was gained and lost when the medieval philosophy was superseded in the seventeenth century by the doctrines of Descartes and Newton. To answer this question it is necessary to examine how the supersession came about. From the fourteenth century onwards, Scholasticism was decadent, and by the end of the sixteenth it had become thoroughly debased. The love of nature that had been so vital in Aristotle had almost perished; the practice of observation and experiment, on which he and St. Thomas had so strongly insisted, was neglected save by a few solitary workers; and the degenerate Schoolmen occupied themselves with futile subtleties that bore no relation to life and reality; they argued about homogeneities and heterogeneities, categorematics and syncategorematics, simpliciter and secundum quid; they resolved questions by the way of "formaliter," "materialiter," "fundamentaliter" and "eminenter"; and showed the causes of things in sympathy, antipathy and the influence of the heavens. No wonder that the virile scholars of the Renaissance broke away from it all. In Italy, under the patronage

of the Medici, there was a revival of Platonism; and at Paris, in 1536, a crowded audience acclaimed the thesis of Peter Ramus, "Whatever is in Aristotle is false."

If philosophy and science were to be restored to life and health, the first necessity was, as Ramus saw, to re-establish contact with the external world. The chief pioneer in the movement back to nature, the great exemplar of the accurate quantitative observation of phenomena, was a friend of Ramus's, the Danish astronomer, Tycho Brahé, who lived from 1546 to 1601, and was thus about twenty years senior to Bacon and Galileo, and a century earlier than Newton. His observations, though made before the invention of the telescope and the micrometer, were astonishingly accurate; and some of his deductions from them were soon seen to be incompatible with the Aristotelian system of the world; thus, his memoir on a new star which appeared in the constellation Cassiopeia in 1572, by showing that this body was situated among the fixed stars, destroyed the belief in the eternal incorruptibility of the heavenly bodies; and his proof that the comet of 1577 moved around the sun in planetary space shattered the cosmology which located comets in the earth's atmosphere.

The work of Tycho firmly established the principle that natural philosophy must be based on quantitative data acquired from observation. But something more was needed in order to consummate the foundation of modern science, and this further element was contributed by his pupil Kepler. Kepler derived his conception from the revived Platonism which was then in favor; but actually it is traceable beyond Plato to his predecessors the Pythagoreans, and it may have been due to Pythagoras himself.

The original Pythagorean discovery related to the lengths of the strings of a lyre: it was found that if a string is stopped at half its length, it gives a note one octave higher; if at two thirds its length, it gives a note higher by the musical interval called a fifth, and so on. Thus simple numerical ratios were shown to exist between the lengths of strings which produce sounds harmonious to each other, and so a connection was set up between mathematics and esthetics. This was generalized into the principle that numerical laws, analogous to the numerical laws of harmony in music, were the proper means of interpreting the fundamental unity of the cosmos; that there must be a mathematical harmony of the external world underlying all phenomena; that this was the reality which philosophers sought, and that the task of men of science was to find it.

Moreover, it was asserted that the dispositions of nature were of the simplest character that could be imagined in any particular case. This consideration,

which has in fact played a part of the first importance in the history of physics—in our own day it guided Einstein to the law of gravitation in curved space—was applied by Kepler in order to simplify the elaborate picture of the world which he had inherited from his predecessors. It is to be remembered that Copernicus, although he took the all-important step of placing the sun in the center of the universe, still retained the intricate machinery of epicycles which had been devised by Hipparchus to represent the motions of the planets, and which, by the successive adjunction of fresh curves to represent new discoveries, had by now become intolerably complicated: so much so that a royal patron of science, to whom it was described, remarked that “if the Deity had consulted him at the creation, he would have given Him good advice.”

It seemed to Kepler that the truth must be much simpler than any one had yet realized; and that by use of the right kind of mathematics it should be possible to exhibit or suggest in some way a physical connection between the planets and the sun as the center of their motions. Eventually he succeeded in showing that the planes of the orbits of all the planets pass through the sun; that all the orbits are ellipses, having the sun as a focus; and that a line joining a planet to the sun sweeps out equal areas in equal times.

By the labors of Tycho and Kepler the modern procedure of science was instituted, and the true structure of the universe was revealed. At this point it may be observed that, while the Scholastic cosmology² was thereby completely disproved and overthrown, there was nothing in the new methods and discoveries that was inherently irreconcilable with the Scholastic metaphysics: the whole of Tycho's and Kepler's work might conceivably have been absorbed into the philosophy of the Schoolmen by a peaceful and conservative revolution. If this had happened, we in the twentieth century should have been spared the necessity of readjusting our position by a movement back towards Aristotelianism; but it was not to be. What did happen was a violent upheaval which swept away ontological doctrines equally with cosmological, destroying the old order entirely; an upheaval out of which the system of classical physics was formed, and which has dominated the relations of science, philosophy and religion with each other down to the present time.

The central figure of the movement on its metaphysical side was Descartes. As a young man he had become familiar with the degenerate Scholasticism of the day; but it had left him dissatisfied. Its conclusions were based principally on the affirmations of the great doctors; but the authority of the doctors was

insecure, and the only branch of knowledge that seemed to be satisfactorily established was mathematics, whose procedure was to set out from self-evident postulates and to deduce from them results of practical value and incontrovertible truth. Descartes conceived the idea of searching for principles as certain as the axioms of mathematics, and on them as foundation to rebuild philosophy.

In pursuance of this design, he proposed far-reaching changes in the philosophy of nature. The first step—evidently suggested by the success of Kepler's work on the planetary orbits—was to describe the happenings of the external world in mathematical language. Now of all things presented to our observation, the spatial dimensions of bodies are the most obviously quantitative; he therefore seized on this feature, and based his system of the world on the affirmation that the characteristic of matter is extension. Another experience which is measurable is the passage of time; and hence the movement of bodies, which may be specified by the distance passed over in intervals of time, also admits of quantitative treatment. In terms of these two concepts matter and movement, Descartes proposed to explain the physical universe: quality was to be made intelligible as varying quantity.

In this scheme, extension constitutes matter, and matter constitutes space, which is therefore a plenum—there is no void. The sensations of sound, light, heat, taste and qualities generally are to be regarded as belonging to our consciousness, and purely subjective: in nature itself there is nothing but extension and the locomotion of its parts; the external world is a purely mechanical assemblage.

In the Cartesian transformation of philosophy the very meanings of the keywords were altered. Thus motion, which to the Scholastics had meant change of any kind, was now restricted to mean change of position; matter, which in the older doctrine was correlative to form, now meant simply corporeal being. Especially noteworthy is the new importance acquired by space and time. The Schoolmen had no word for “space” as we understand it; for spatium had rather the sense that “space” has in the Authorized Version of the Bible, *e.g.*, “All with one voice about the space of two hours cried out, ‘Great is Diana of the Ephesians’ ”³; while locus meant the space occupied by a particular body. “Where” and “when,” which to the Scholastics had been merely two among the ten predicaments of being, now came to dominate completely the description of nature.

That description was even more strictly mechanical than the Newtonian description which later superseded it, as may be seen, for instance, in their re-

² The word “cosmology” is here used in the sense that is customary in modern scientific writing, not the wider sense in which it is used in Scholastic philosophy.

³ Acts xix, 34.

spective conceptions of gravitation. Gravity had been classified by the Schoolmen as an "occult quality"—that is to say, a force or tendency produced by no visible agency. Descartes denied the existence of occult qualities, and maintained, like the Greek atomists, that impact was the only mode in which one body could affect another: consequently he was compelled to furnish a new explanation of the fall of bodies towards the earth. This he did by postulating that surrounding the earth there is a vortex of subtle matter, or ether, which, by its pressure, provides the effect of gravity. Newton, on the other hand, formulated the inverse-square law without providing any mechanism to account for it; and in the preface to the second edition of the "Principia" there is a frank reversion to the Scholastic view of gravity as an occult quality.

Thus in the picture of the world arrived at by Descartes, all the phenomena of astronomy and physics, so far as they were known at the time, were represented by aggregations or motions or pressures in the plenum of space. Nothing resisted his mechanical explanations, except the thought of man; this could not be brought into any relation with extension, and was evidently not amenable to mathematical analysis. It must, therefore, he concluded, have a principle other than matter; and thus he arrived at a dualistic philosophy, and divided reality into the two great classes of extended and thinking substances, *res extensa* and *res cogitans*, the objective and the subjective, the corporeal and the spiritual world. As matter is characterized by extension, so the mind is characterized by thought: the two are completely independent, and no explanation of any relation between them is forthcoming.

The complete disjunction of the psychical from the physical, which was characteristic of Cartesianism, has profoundly affected the subsequent history of science, and indeed of almost every department of human thought. In the first generation after Descartes there was an uneasy recognition of the possibility that—since any view of the cosmos must have a theological bearing—the new natural philosophy might prove harmful to religion; and in fact a keen controversy broke out on this very question. The dispute was centered round the doctrines of space and time, which in this period underwent a profound change.

The principal agent of the change was Pierre Gassendi (1592-1655), who, opposing Descartes' representation of space as a plenum, revived the doctrines of the ancient atomists regarding the void. This implied making a distinction between matter and extension, and asserting that while space has extension, matter has solidity as well, and occupies only a part of space. Gassendi's ideas were adopted by Newton, and thus was evolved the portrayal of space and time

which became finally established in classical physics. Its fundamental postulate is that all the phenomena of the external world can be described in terms of the location and motion in space of entities, each of which has some degree of persistence and continuous identity in time. Thus whatever happens, happens in space—space, the stage on which the drama of physics is to be played, is the dominating conception of the whole system. This had not been at all the point of view of Scholasticism, and, as we shall see later, the recent progress of physical discovery has shown that it is radically unsound.

By Newton, space is regarded as having a positive, objective existence, which is not attached in any way to subjective necessities of the human mind. "Absolute space," he says, "in its own nature, without regard to anything external, remains always similar and immovable"⁴ and "all things are placed in space as regards order of situation."⁵ It is a real entity, subsisting prior to, and independently of, the bodies which it contains; and all events in nature can be represented by movements within it. Every point of space persists throughout an infinite succession of instants of time, and the notion of simultaneity is valid, with all the implications which it carries in classical physics. In the Gassendi-Newton scheme it is not considered necessary to account for the existence of entities which are permanent over appreciable durations of time, such as (in the earlier period) particles of matter: these are postulated, and the aim of science is to explain the changing phenomena of the universe in terms of their motions. Persistence of bodies in time and their displacement in space are the concepts to which everything in the external world is to be reduced.

The attempt to fit this doctrine into the framework of philosophy and theology was confronted by the difficulty that besets all systems based on the Cartesian bifurcation between mind and matter, namely, that no provision is made for the interaction of spiritual with corporeal being. A possible solution seemed to be indicated by an idea put forward in 1647 by the Cambridge Platonist Henry More, that in some part of the human brain there is a *sensorium* or organ of internal sensation where the understanding resides, to which the images of external things are conveyed by the organs of sense, and where they have a "tactual conjunction" with the soul, which thus perceives them. Newton now boldly suggested that space might be the Sensorium of God. "Does it not appear from phenomena," he said,⁶ "that there is a Being incorporeal,

⁴ "Spatium absolutum, naturâ suâ sine relatione ad externum quodvis, semper manet simile et immobile," "Principia," *Schol. ad. Defn.*

⁵ "In spatio quoad ordinem situs locantur universa," *ibid.*

living, intelligent, omnipresent, who in infinite space, as it were in his sensory, sees the things themselves intimately, and thoroughly perceives them, and comprehends them wholly by their immediate presence to himself?"

The idea that God had to be fitted into a scheme of which matter, space and time were the primary concepts was attacked by Leibnitz, who rejected altogether the doctrine of an absolute space and time having reality outside our minds, and maintained that space is only a conceptual entity, an order according to which situations are disposed, and time is only an order of succession. His argument against Newton may be put in a modern form somewhat as follows: During the operation of "summer time" the clock is an hour ahead of Greenwich time. This fact is, however, not made evident by any of the ordinary happenings of life, since all clocks, departures of railway trains, office hours, mealtimes and so forth, bear to each other the same relations as before: in order to detect the change we have to observe something which does not obey the Act of Parliament establishing summer time, such as the moment of sunset. Now suppose that some way could be found of compelling the heavenly bodies to adapt themselves to summer time on the same day as our clocks: then, after this, it would be impossible by any observations whatever to tell which kind of time we were keeping: the only evidence would be that furnished by memory—the recollection of the day which had only 23 hours, when the clocks were put forward. Let us now imagine that day to recede into the past, back to the creation of the world. Would there then be any difference between the two systems? Or to put the same question in another form, is there any meaning in the statement that God might have created everything an hour sooner? Newton would say, Yes. Leibnitz would say, No. I leave the fellows of the society to form their own judgment on the matter.

Another count in Leibnitz's indictment of Newtonianism related to the concept of force, the *vis motrix* of the "Principia," which in the case of gravity was represented as acting at a distance. "Some men," wrote Leibnitz, "begin to revive, under the specious name of 'forces,' the occult qualities of Scholasticism; but they bring us back again into the Kingdom of Darkness." Now "force" in its statical sense, as, for instance, when we speak of "the force exerted by the weight of one pound," was a familiar idea to the Schoolmen: their physics included what they called *scientia de ponderibus*, which dealt with such matters as the law of equilibrium of the lever and the apparent weight of a body resting on an inclined plane.

But the kinetic relations of force were unknown in the Middle Ages, and were first formulated in the "Principia," in the Second Law of Motion, which equates force to the product of mass and acceleration.

Newton showed how the known connection between forces and accelerations made it possible to write down equations, by which the motion could be determined. But before long it was found that, at any rate when the system studied was only a single particle, the motion could be calculated without bringing in forces or accelerations, by making use of what would now be called the principle of conservation of energy. When a pendulum is drawn to one side, so that the bob is higher than when it is hanging vertically, it has energy in the potential form (in this case due to gravitation); when the pendulum is released, it begins to swing, the potential energy being changed into energy of motion. This way of regarding dynamics shows a certain affinity with the Scholastic philosophy; for the physics which the Schoolmen appropriated from Aristotle was dominated by the idea that there are two ways of Being, potency⁸ and act,⁹ and that all change is a transition between a state which is potential and a state which is actual.

For a problem in classical mechanics there is of course no contradiction between the solution which is obtained by using the concept of potential energy and the solution by the original Newtonian method which uses the concept of force: the two are mathematically equivalent. But in the present century it has been found that the mutual influence between elementary particles is governed not by the laws of classical mechanics but by those of quantum mechanics, in which the concept of force is abolished and the interaction is represented by a term corresponding to the potential energy of classical mechanics, but of a more abstract character; it is called an operator, and, like potential energy, may be attached to the Aristotelian concept of potency.

To return to classical physics, a further change in its outlook was brought about by the discovery of what are called minimum-principles. A simple example is afforded by the hanging chain. Suppose that a chain is suspended between two points of support: what will be the curve in which it will dispose itself? We all know the general appearance of the curve: it is something like an arc of a circle joining the two points of suspension. Actually it is not part of a circle, but a curve known as a catenary: this was discovered towards the end of the seventeenth century by the Newtonian method of considering the forces which act between consecutive links of the chain. The problem may, however, be solved in a quite different way, with-

⁸ *Opticks*, Qu. 28.

⁹ "A Collection of Papers which passed between Mr. Leibnitz and Dr. Clarke" (London, 1717), p. 265.

⁸ *δύναμις*, *potentia*.

⁹ *ἐνέργεια* or *ἐντελέχεια*, *actus*.

out introducing the idea of force, by assuming that the chain arranges itself in such a way as to make its center of gravity have the lowest possible position. This assumption, that the height of the center of gravity is a minimum, is a typical minimum-principle. At least one minimum-principle was known to the ancient Greeks, namely, that when a ray of light issuing from a source is reflected at a mirror and afterwards received by an observer, then the path followed by the incident and reflected rays is shorter than any other path from the source to the observer which meets the mirror.

By a succession of discoveries it was shown that all the happenings of nature can be predicted by means of minimum-principles: the climax was reached in 1915, when Hilbert showed that all physical events (gravitational, electrical, etc.) in the universe are determined by a "world-function" which is such that its integral taken over the whole of space-time is a minimum. Such a statement as this has a decidedly Aristotelian character; for, in studying change, Aristotle always fixed his attention on the end to be fulfilled: his science was essentially teleological. Again we see how classical physics, following its own natural development, tended to deviate from the pattern devised by Newton and to return to the Aristotelian-Scholastic mould.

A change in orientation such as this, however, did not affect the fundamental assumptions of Newtonian science. We have now to consider developments of a far more subversive nature.

The first serious trouble arose in connection with the doctrine of space. The space of Gassendi and Newton was, so far as geometry was concerned, the space of

Euclid: it was infinite, homogeneous and completely featureless, one point being just like another; so far as physics was concerned, it was like the vacuum of the ancient atomists, mere emptiness into which things could be put. From the philosophical point of view this concept was open to the objection that Aristotle had urged against the doctrine of the atomists, namely, that if space were devoid of local properties, the tendency of a body to move spontaneously in a particular direction (*e.g.*, the existence of a gravitational field, as we should say) would be unintelligible. As a matter of fact, the successors of Newton felt this difficulty; and, having started with a space which was in itself simply nonentity, having no property except a capacity for being occupied, they proceeded to fill it several times over with ethers designed to provide electric, magnetic and gravitational forces, and to account for the propagation of light; and as it was impossible to draw any effective distinction between those ethers and space, Newtonian space became eventually a plenum of the most elaborate kind, possessing such qualities as density and rigidity everywhere. Its points were capable of individual identification, and could be regarded as fixed; and having thus acquired a more definite and concrete substantiality than Newton himself had ever contemplated, its absolute character became an essential and inseparable axiom of classical physics. But the discovery in 1905 of the principle of relativity led to inferences incompatible with the existence of any kind of quasi-material ether: and thus the Gassendi-Newton doctrine became involved in hopeless contradiction.

(To be concluded)

OBITUARY

ALEŠ HRDLÍČKA

March 29, 1869–September 5, 1943

ALEŠ HRDLÍČKA was born of worthy middle-class parents at Humpolec, Bohemia. In 1882 the family moved to New York. There, in 1892, he got a degree at the Eclectic Medical College of the City of New York and in 1894 from the New York Homeopathic Medical College. Soon after he joined the staff of the State Homeopathic Hospital for the Insane at Middletown, N. Y., and also became affiliated with the Pathological Institute of the N. Y. State Hospitals. His early years with the mentally and physically abnormal convinced him of the need for knowing the normal, and this became the guiding principle of his entire scientific life.

Dr. Hrdlička was truly a prodigious worker, both in the laboratory and in the field. In 1898 he took his

first field trip, with Humboldt to Mexico, where he studied the Tarahumares, the Huichols and the Tepehuanes. These trips were continued in 1899–1902, to the southwestern United States and northern Mexico, under the auspices of the Hyde expeditions of the American Museum. He had an unusual ability to "get along" with natives, and these field trips were very fruitful. They were the first of many that took him all over the world: to Egypt and the Near East in 1909, to Siberia and Mongolia in 1912, to Peru in 1913, to the Far East in 1920, to Africa, Asia and Oceania in 1925, to Alaska and the Aleutians in 1926–38, to Russia and Siberia in 1939, besides numerous trips to Europe and expeditions within the United States.

In 1903 Dr. Hrdlička became assistant curator and in 1910 curator of the Division of Physical Anthro-

pology of the U. S. National Museum, a position which he held until his retirement in 1941. In this capacity he published countless articles and many books. Among the latter are: "Skeletal Remains Suggesting or Attributed to Early Man in North America" (1907, 1918); "Physiological and Medical Observations among the Indians of Southwestern United States and Northern Mexico" (1908); "Early Man in South America" (1912); "The Most Ancient Skeletal Remains of Man" (1914, 1930); "Anthropometry" (1920); "The Old Americans" (1925); "Anthropological Survey of Alaska" (1930); "Children Who Run on All Fours" (1931); "Practical Anthropometry" (1939); "Alaska Diary" (1943); "Catalogues of Human Crania in the U. S. National Museum" (1924, 1925, 1927, 1928, 1931, 1942).

In 1896 Dr. Hrdlička married Marie Dieudonnee, of New York City. Her death in 1918 was greatly mourned. In her honor there was established the "Aleš and Marie Hrdlička Foundation" in Czechoslovakia, which subsidized, in part at least, a chair of anthropology at the Charles University in Prague and the Czech journal *Anthropologie*, in publication since 1923.

Dr. Hrdlička's greatest contributions were in founding the *American Journal of Physical Anthropology*, of which he was editor from 1918-1942, and in establishing in 1929 the American Association of Physical Anthropologists, of which he was president from 1929 to 1932. To the journal he gave unstintingly of time, energy and devotion; in its formative years he was its financial "angel." To the association he gave years of wisdom and a rare, sympathetic insight into human nature. He was jealous of the reputation of the "science of anthropometry," feeling that "it will be practiced as long as man is interested in the study of his

kind." In protecting this reputation he at times leaned over backward to guard against what to him seemed impractical innovations or extravagant or unwarranted claims and deductions.

Many honors came to Dr. Hrdlička: the chairmanship of the Anthropological Society of Washington (1907), Section H of the A.A.A.S. (1918), of the American Anthropological Association (1925-1926) and of the Washington Academy of Sciences (1929). He had an honorary Sc.D. from Prague (1922) and Brno (1926). He was a member of the National Academy of Sciences and of the American Philosophical Society.

In the Epilogue to "Alaska Diary" Dr. Hrdlička speaks of the volume as the views of "a medical man, an anthropological explorer, and a human human . . . a story of sustained, systematic assiduous search for evidence that might aid in clearing the aboriginal history of (Alaska)." This says what we all feel toward his memory: he was a great scientist, but first he was a warm-hearted, unselfish, lovable human being.

WILTON MARION KROGMAN

UNIVERSITY OF CHICAGO

RECENT DEATHS

DR. FREDERICK PAUL KEPPEL, dean of Columbia College from 1910 to 1918 and from 1923 to 1941 president of the Carnegie Corporation, died on September 8. Since his retirement he had served with the State Department in Washington as a member of the Board of Appeals on Alien Cases.

Nature reports the death of T. J. Jehu, emeritus regius professor of geology of the University of Edinburgh, and at the age of fifty-eight years of Sir Stopford Brunton, Bt., the Canadian mining geologist.

SCIENTIFIC EVENTS

GIFTS AND GRANTS TO THE UNIVERSITY OF ILLINOIS

TWENTY-NINE gifts and grants to the University of Illinois amounting to more than \$127,000 were reported at the last meeting of the Board of Trustees. They are for research, for scholarships and for special items such as books.

The largest of the grants was \$75,000 from the Upjohn Company, Kalamazoo, Mich., for a three-year study of the synthesis of penicillin which will be conducted by the department of chemistry, and in addition the company has provided \$1,200 for a post-doctorate research assistantship in chemistry.

The sum of \$1,200 was received from the Nutrition Foundation, Inc., New York, in support of research into the amino-acid requirements of man and of \$2,400

to support research on calcium utilization by man. Grants were made by the William S. Merrell Company of \$7,500 for fellowship stipends to support research in chemistry; by the John and Mary R. Markle Foundation, New York, \$7,000 in support of research on high blood pressure; by the Allied Chemical and Dye Corporation, two fellowships in organic chemistry of \$750 each; by Sharpe and Dohme, Philadelphia, \$1,500 for study of certain animal diseases; by Cerophyl Laboratories, Kansas City, \$1,200 for research in botany; by the Monsanto Chemical Company, St. Louis, \$4,500 for a research fellowship on insecticides; by the Eastman Kodak Company, \$1,000 for a fellowship in chemistry.

A gift of \$500 was made by the W. K. Kellogg Foundation, Battle Creek, Mich., to the College of

Dentistry for student aid; The Farm Foundation, Chicago, gave \$425 toward work of the Land Tenure Committee of the North Central States; the Illinois Congress of Parents and Teachers gave \$400 for annual scholarships, and Mrs. Kittie B. Pierce gave \$300 for the Phyllis Pierce Ruettinger scholarship fund.

FIELD MUSEUM OF NATURAL HISTORY

FIELD MUSEUM OF NATURAL HISTORY will be fifty years old on September 16. The following is an official summary of events of importance in the history of the museum.

A charter was obtained on September 16, 1893, under the title, Columbian Museum of Chicago. The name was changed in 1894 to Field Columbian Museum, and it was again changed in 1905 to the present form, Field Museum of Natural History.

Much of the sum originally subscribed in cash—\$1,443,408—necessarily had to be expended during the early years to purchase collections, exhibition cases and equipment, and to defray organizing and administrative expense.

Under the will of Marshall Field, whose death occurred on January 16, 1906, \$8,000,000 was bequeathed to the museum with the stipulation that \$4,000,000 was to be added to the endowment fund and \$4,000,000 was to be used for the construction of a new building. This bequest of Mr. Field's brought the total amount of his gifts to \$9,430,000.

For three years prior to the completion of the present building, the efforts of the entire staff were devoted to packing the collections and preparing them for transfer from the original building in Jackson Park. Actual moving started on April 26, 1920. A railroad spur was built through Jackson Park to the old building, and another was built to the new building, and all the collections, exhibition cases and equipment were moved by the use of freight cars and trucks. By May 2, 1921, the new museum building was opened.

Since the founding of the museum, 440 expeditions have gone out to all parts of the world, and this number does not include many hundreds of small trips classified as local field work.

The collections shown in exhibition cases are but a small part of the total. In research, the study collections of museums are of the greatest importance. They are used by scientific men from all over the world and are the basis of much of our present-day knowledge. Those at Field Museum rank high both in extent and in usefulness.

During the fifty years under review, the museum has printed 566 scientific publications, most of them the results of its own expeditions and research. It

has also published eighty-eight leaflets written in popular style.

Field Museum Library contains approximately 130,000 books and pamphlets on anthropology, botany, geology, zoology and related subjects, and offers the largest reference collection in its special fields in Chicago.

It is interesting to note that during the museum's occupancy of the old building in Jackson Park, from June 2, 1894, to February 23, 1920, a period of approximately twenty-six years, the attendance was 5,839,579, whereas the attendance in the present building from May 2, 1921, to June 16, 1943, approximately twenty-two years, has been 27,576,728.

The museum has realized the importance of exhibiting all types of material in a way that would attract and educate the layman visitor. It was among the first to install animal habitat groups in natural settings.

THE THIRD NATION-WIDE SCIENCE TALENT SEARCH

THE third annual Science Talent Search, for promising scientific ability among high-school graduating seniors, will be conducted during the fall and winter months of the school year.

Open alike to boys and girls, the search will enlist the aid of high-school principals and teachers who will administer tests and supply other necessary data. Westinghouse Science Scholarships amounting to the sum of \$11,000 will be awarded to at least ten, and possibly forty, of the successful contestants. In addition, all forty will attend a five-day Science Talent Institute on an all-expense trip to Washington next February.

In the second Talent Search, completed last spring, some fifteen thousand seniors requested examinations, three thousand, four hundred completed the requirements and two hundred and sixty were awarded honorable mention. Of the forty taken to Washington, eleven were girls and twenty-nine boys.

Watson Davis, director of Science Service, said that students in public, private and parochial schools desiring to enter the Science Talent Search this fall will take a special aptitude examination under supervision of school officials in their home communities between December 3 and 27. The forty who pass the examination, and qualify on the basis of personal and scholarship records and essays, will be named delegates to the institute.

Final examinations during sessions of the institute will determine the award of two four-year Westinghouse Science Grand Scholarships of \$2,400 each and eight four-year Westinghouse Science Scholarships of \$400 each. One boy and one girl will be selected

to receive the Grand Scholarships. The Westinghouse Electric and Manufacturing Company provides the scholarship awards as a contribution to the advancement of science in America. Additional Westinghouse scholarships amounting to \$3,000 will be awarded at the discretion of the judges. If any scholarship recipient should be drafted or enter other government war service, his scholarship will be held for his use later.

NEW AND RARE INSTRUMENTS

URGENT requests for instruments difficult or impossible to obtain through customary channels continue to reach the Committee on Location of New and Rare Instruments. Many of these can be filled and vital research projects greatly helped. Particularly needed are sensitive electrical instruments (milli- and micro-volt and ammeters) and usable optical instruments or parts.

Requests in the hands of the committee that remain unfilled are:

- Pressure autoclaves
- Metallurgical microscopes
- Polarizer and Analyzer for microscopes
- Abbe refractometers (16 requests)
- Strobotaes
- L. & N. Portable Thermocouples
- Cenco Impulse Counters

Instruments available through the committee include:

- Various balances
- S. & H. Colorimeters
- L. & H. H ion meter
- Microtomes
- pH apparatus
- Polarimeters
- Potentiometers
- Pyrometers
- Hilger-Spekter Spectrophotometer
- Viscosimeters

Instruments are requested for both loan and outright purchase. Those who have instruments that they can spare should send a list of them to D. H. Killeffer, chairman, 60 East 42d St., New York 17, N. Y.

AVAILABLE TEACHERS OF COLLEGIATE MATHEMATICS

THE Committee on Available Teachers of Collegiate Mathematics, established by the War Policy Committee of the American Mathematical Society and the Mathematical Association of America, has been in existence since the beginning of April, 1943. During this time it has received and answered numerous inquiries from colleges and universities needing teachers of mathematics, as well as from teachers who were free to accept appointments.

It is anticipated that the demand for teachers will increase considerably during the next two or three months. On the other hand, the number of available well-qualified candidates who have registered with the committee for such appointments has been reduced to such an extent that the remaining supply has become quite inadequate to meet the expected demand.

For this reason, the committee requests departments of mathematics to inform them at the earliest possible date (a) of their needs during the next half year, giving as full details as they can concerning the qualifications expected, the salary offered and other pertinent facts relating to their vacancies; (b) of members who are free to fill temporary positions in other institutions.

The committee would also appreciate hearing from individual teachers.

Committee on Available Teachers,
W. D. CAIRNS
ARNOLD DRESDEN
J. R. KLINE

110 BENNETT HALL,
UNIVERSITY OF PENNSYLVANIA

THE WOODS HOLE MARINE BIOLOGICAL LABORATORY

RESEARCH and teaching at the Marine Biological Laboratory at Woods Hole, Mass., has continued as usual during the summer although, owing to war-time conditions, on a reduced scale, according to an article by Dr. Charles Packard, director, in a forthcoming issue of *The Collecting Net*. Approximately half the normal number of investigators and students attended the sessions this season.

The United States Navy continues to occupy the mess hall of the laboratory, the old lecture hall and the botany building as well as the apartment house and one of the older residential buildings. The laboratory has taken over an inn several blocks from the main building which it operates effectively.

Friday evening lectures were given as usual this season. The speakers were Drs. W. R. Taylor, D. P. Costello, P. S. Galtsoff, R. T. Kempton, L. V. Heilbrunn, Kurt G. Stern, B. M. Duggar and A. H. Woodcock. The regular weekly seminars were discontinued. For the first time for over fifty years the course in botany was omitted because of insufficient registration.

The financial condition of the laboratory is satisfactory, and funds are available to meet current expenses. However, this is being done partly with money previously used in paying for subscriptions to foreign journals.

At the meeting of the corporation in August Professors W. E. Garrey and B. M. Duggar were made trustees emeriti, and in their places Dr. P. S. Galtsoff, senior biologist in the U. S. Fish and Wildlife Ser-

vice, and Dr. E. W. Sinnott, professor of botany at Barnard College, Columbia University, were elected to complete their four-year terms. Dr. Otto Glaser, professor of biology at Amherst College, was reelected clerk of the corporation. Memorials were read for Gary Nathan Calkins and Hermon Carey Bumpus, who died during the year, both of whom had been members of the corporation for nearly fifty years. An expression of appreciation for Dr. Lillie's long and valuable services was read. Dr. Lillie retired from the presidency of the corporation in 1942 after more than forty years of service as administrator of laboratory affairs.

At the meeting of the trustees seven new members were elected to the corporation. It was the sense of

the meeting that the attendance at the laboratory after the war would not only equal that of 1940 (when 336 investigators and their assistants represented 148 institutions) but that it would greatly exceed it. In anticipation of this expansion a committee on additional funds, consisting of Drs. D. E. S. Brown, *chairman*, F. R. Lillie, E. G. Conklin, E. N. Harvey, G. H. A. Clowes (with Laurence Riggs, Dr. C. Packard and D. M. Brodie as *ex-officio* members), has formulated plans for setting up teaching fellowships and scholarships for biologists who would work in Woods Hole throughout the year; for securing funds for a new building to replace the old main building and the other wooden laboratories, and for additional endowment.

SCIENTIFIC NOTES AND NEWS

THE Julius Friedenwald Medal of the American Gastroenterological Association has been awarded to Dr. Thomas R. Brown, associate professor of medicine emeritus of the School of Medicine of the Johns Hopkins University. The July issue of *Gastroenterology* was dedicated to Dr. Brown "in recognition of his many accomplishments as a clinician and a teacher and to mark his contributions in the field of gastroenterology."

It is reported in *The Times*, London, that the joint advisory committee of the Wellcome Foundation and the Veterinary Educational Trust has awarded the first Wellcome Junior Fellowship for Veterinary Research to John Lochiel McGirr.

DR. FREMONT A. CHANDLER, associate professor of orthopedic surgery at the Medical School of Northwestern University, has become professor of orthopedic surgery and head of the department at the College of Medicine of the University of Illinois, Chicago.

DR. RICHARD J. WINZLER, research fellow of the National Cancer Institute, has been appointed assistant professor of biochemistry at the Medical School of the University of Southern California, Los Angeles.

DR. SAUL GERALD COHEN, of the Converse Memorial Laboratory of Harvard University, has been appointed a national research fellow to work under Dr. William G. Young, chairman of the department of chemistry of the University of California at Los Angeles.

DR. ELIZABETH BINDLOSS JOHNSON has been appointed to an assistant professorship in botany at Connecticut College, and Dr. Betty F. Thomson to an instructorship. The former returns to Connecticut after two years at Wellesley College; the latter has held a similar teaching position at the University of Vermont.

H. C. SHETRONE, director of the State Archeological and Historical Society of Columbus, Ohio, was elected at the recent annual meeting president of the Ohio Academy of Science.

OFFICERS of the newly organized Society for Research in Psychosomatic Problems are Dr. Winfred Overholser, Washington, D. C., *president-elect*; Dr. Tracy J. Putnam, New York, *president*, and Dr. Edwin G. Zabriskie, New York, *secretary-treasurer*. Dr. Adolf Meyer, professor of psychiatry emeritus, of the School of Medicine of the Johns Hopkins University, was elected honorary president.

DR. ROBERT P. FISCHER, secretary and chief chemist of the Board of Pharmacy of the State of New Jersey, has been reappointed for a term of four years a member for pharmacy of the New Jersey State Board of Health.

At the recent annual meeting of the British Genetical Society the following officers were elected: *President*, Dr. C. D. Darlington; *Vice-presidents*, Dr. R. N. Salaman, Professor T. J. Jenkin, Professor R. A. Fisher; *Treasurer*, Miss E. R. Saunders; *Secretaries*, E. B. Ford, University Museum, Oxford; W. J. C. Lawrence, John Innes Horticultural Institution.

DR. CARLETON R. BALL, principal agriculturist and executive secretary of the correlating committee of the U. S. Department of Agriculture, the Tennessee Valley Authority and the Valley-States Land-Grant Colleges, retired on June 30. Appointed a collaborator, he has an office with the Extension Service of the department. Uncompleted projects now under way include "Federal, State and Local Administrative Relations in Natural Resources," a monograph of the willows, a volume on agricultural history in America and one on how to write technical manuscripts.

DR. HARRY S. GANDERS, dean of the School of Education of Syracuse University, has been appointed acting dean of the Graduate School. He succeeds Dr. William L. Bray, who retired on September 1.

BRADLEY DEWEY, president of the Dewey and Almy Chemical Company, deputy rubber director to William M. Jeffers, who resigned on September 4, has been appointed to succeed Mr. Jeffers, with the title of acting rubber director.

DR. M. R. BENEDICT, professor of agricultural economics at the University of California at Berkeley and agricultural economist of the Giannini Foundation, is now in Washington, D. C., where he will act as consultant on food for the Office of Lend-Lease Administration. Professor Benedict will return to the College of Agriculture on February 29, the beginning of the spring term.

ROBERT R. WEST, president of the Esmond Mills, has been appointed chairman of the committee on economic research of the Textile Research Institute. The principal function of the committee is to recommend to the institute important projects in economic research and to supervise their production.

DR. FLORENCE CLYDE CHANDLER, technical research assistant to Dr. A. B. Stout, has resigned from the scientific staff of the New York Botanical Garden in order to participate in a project of breeding cinchona for high yields of the alkaloids which include quinine.

THE Committee of the British Privy Council for Agricultural Research has appointed Lord De La Warr to be chairman of the Agricultural Research Council in succession to the late Sir Thomas Middleton. The committee has also appointed Professor I. de Burgh Daly, F.R.S., to be a member of the Agricultural Research Council in the place of Sir Joseph Barcroft, F.R.S., whose term of office as a member has expired.

DR. GEORGE B. CRESSEY, chairman of the department of geography and geology of the University of Syracuse, has leave of absence to accept an appointment as representative of the United States Department of State in China. The appointment is in connection with Cultural Relations in China of the department. Dr. Cressey will work at the Chinese universities.

EARLY in July, Dr. Frank H. H. Roberts, Jr., of the Smithsonian Institution, spent five days in the Abilene, Texas, region with Dr. Cyrus N. Ray examining a stratified river bank burial situated twenty-one feet below the soil surface and eight other deeply buried widely separated stream bank midden sites located on three different water courses of the region. Among those visited were the McLean and Gibson sites and the sites in the Matthews and Putnam ranches.

MRS. GRACE NEEDHAM OLIVER, assistant in mineral economy in the Illinois State Geological Survey and editor for several years past of the *Transactions* of the Illinois State Academy of Science, has moved to Washington, where her husband, Dr. Revilo P. Oliver, is engaged in war service. Miss Dorothy E. Rose, technical editor for the Illinois State Geological Survey, will serve in Mrs. Oliver's place as editor for the Illinois Academy.

THE fourth conference on Science, Philosophy and Religion in their Relation to the Democratic Way of Life opened at Columbia University on September 10. All the papers presented dealt with some aspect of the problem of abolishing war. The chairmen of the various sessions were Dr. Charles W. Hendel, professor of moral philosophy, and Dr. Mark A. May, director of the Institute of Human Relations, Yale University; Dr. Harlow Shapley, director of the Harvard Observatory; Dr. Harry A. Overstreet, professor emeritus of philosophy, College of the City of New York; Dr. Lyman Bryson, professor of education, Teachers College, Columbia University; the Reverend Hunter Guthrie, Georgetown University; Dr. Robert M. MacIver, professor of sociology, Columbia University, and the Reverend Gerald P. Phelan, the Pontifical Institute of Mediaeval Studies, Toronto, Canada.

AT the twenty-fifth annual National Metal Congress in Chicago during the week of October 18 presentation will be made of two newly established medals. These are the Gold Medal and the Medal for the Advancement of Research of the American Society for Metals, which will be awarded during the annual dinner at the Palmer House on October 21. The Gold Medal will be awarded to one recognized for outstanding metallurgical knowledge who has shown great versatility in the application of science to the metal industry. He will have exhibited exceptional ability in the diagnosis and solution of diversified metallurgical problems relating to different fields of metallurgy of one metal or individual fields applied to several metals. This award will comprise a gold medal, certificate and citation, and will be given only as often as a candidate of exceptional merit can be recognized. The recipient of the Research Medal will be an executive in an industrial organization the principal activity of which is the production or the fabrication of metals. He will be one who, over a period of years, has consistently sponsored metallurgical research or development and by his foresight and his influence in making available financial support has helped substantially to advance the arts and sciences relating to metals. This award will consist of a medal, plaque and citation.

THE fourth meeting of the Anglo-American Caribbean Commission, under the United States co-chair-

man, Charles W. Taussig, opened on August 17 at Charlotte Amalie, St. Thomas, Virgin Islands. According to *The Times*, London, the British representatives included the British co-chairman, Sir Frank Stockdale, and A. J. Wakefield, inspector-general of agriculture in the West Indies, who has been nominated a British member for the meeting. There was established a Caribbean Research Council which will serve in an advisory capacity for scientific, social and economic research for the benefit of the people of the area. The main subject of the agenda was agricultural research. The commission therefore invited representatives from the agricultural experimental stations of the United States, Great Britain and the Netherlands in the Caribbean area to attend. It adopted as the basis of the discussions the recommendations and report of the United Nations Food Conference at Hot Springs with the object of providing for coordinated effort in the planning of agricultural and other research in the Caribbean by the research institutes and experimental stations represented. These recommendations will also assist the commission in its study of nutritional, agricultural and fisheries problems.

ACCORDING to *The Experiment Station Record*, largely because of the establishment of other organizations now carrying forward its avowed objects decision has been reached to dissolve the Tropical Plant Research Foundation. Its assets are to be divided, the Inter-American Institute of Agricultural Sciences of Turrialba, Costa Rica, receiving the Tropical Agricultural Library and the Boyce Thompson Institute the office equipment. The residual cash and bonds, expected to net about \$4,500, are to be given to the Division of Biology and Agriculture of the National Research Council for use in the promotion of tropical agriculture.

THE Tufts College Medical School, Boston, will

celebrate its fiftieth anniversary from September 15 to October 6. According to the *Journal* of the American Medical Association, the program includes an address at the medical school, on September 15, by Major General James C. Magee on "Military Medicine with Special Reference to Tropical Diseases"; a lecture before the William Harvey Society on September 16 at the Beth Israel Hospital by Dr. Timothy Leary, professor emeritus of pathology at the school, on "Excess Cholesterol as a Pathogenic Agent," and a talk on September 29 by Colonel Raymond W. Bliss. On September 22 a feature of the celebration will be the presentation and unveiling of portraits of Dr. Leary and Dr. Cadis Phipps, professor of medicine. The anniversary exercises will conclude on October 6 with a general meeting at the John Hancock Hall, at which the speakers will include Dr. Leonard Carmichael, president of Tufts College, and Captain A. Warren Stearns, of the Medical Corps, U. S. Naval Reserve, dean of the medical school, now on military leave. Another feature of the celebration will be the release of a book on the history of the Tufts College Medical School, written by Dr. Benjamin Spector, professor of anatomy and professor of the history of medicine, which is said to be the first published history of the school.

It is stated in *The Experiment Station Record* that under appropriations of the 1943 legislature additional substations have been established in Cumberland and Robertson Counties, Tennessee, the former to serve the Cumberland Plateau and the latter the Highland Rim region of middle Tennessee. This increases the number of experimental units in the state from five to seven and has led to the provision of an assistant station director. Frank S. Chancee, superintendent of the Tobacco Substation at Greeneville, has been appointed to this position.

DISCUSSION

THE DISCOVERY AND DEVELOPMENT OF POTASH IN TEXAS AND NEW MEXICO PERMIAN

DR. J. W. TURRENTINE has recently issued through the American Chemical Society a book on "Potash in North America" reviewing the developments from 1924 to the present. In addition to the records he cites there, attention should be called to the contributions of some of the early workers in this field.

Dr. C. W. Dabney, former Assistant Secretary of Agriculture, writes to me that "the biggest find of potash was the one in the Texas-New Mexico Permian, discovered by Dr. J. A. Udden, geologist of the Bureau of Economic Geology and Technology of Texas and published in *Bulletin* 17, March 20, 1917, University of Texas." He describes this as "the first discovery of

potash in Texas." Dr. Dabney presented a paper on the subject at the meeting of the American Association for the Advancement of Science, in December, 1923, at Cincinnati, Ohio.

Dr. W. B. Phillips, the chemist and director of the bureau, was at one time associated with Dr. Dabney in North Carolina. Dr. Dabney took a great interest in the search for American sources of potash and did everything in his power to interest the U. S. Geological Survey and to help the survey to obtain appropriations to make an adequate survey. The chief of the survey, George Otis Smith, sent a survey party to investigate. They reported that they found potash in some one hundred places where drillings had been attempted.

Udden's discoveries, according to Dr. Dabney, were

fully described by Mansfield and Long in *Bulletin* 3401 of the University of Texas, and by H. I. Smith, of the U. S. Geological Survey, and in an article on "Potash in the Permian Salt Basin" in the *Journal of Industrial and Engineering Chemistry*, Vol. 30, page 854.

Dr. Dabney interested Senator Morris Sheppard and Representative Ganner in the subject and a bill authorizing \$2,500,000 for surveys passed the Senate. The House Committee was ready to recommend a similar bill, but the Bureau of the Budget advised that the program was not in accord with the program of the President, so nothing further was done. What was accomplished was done with meager funds available from the U. S. Geological Survey and the State of Texas.

I am calling attention to these facts so that due credit may be accorded to these pioneer workers.

ALBERT F. WOODS

GRADUATE SCHOOL,

U. S. DEPARTMENT OF AGRICULTURE

"CHEMICAL" SEED TREATMENTS

AN item in *SCIENCE-SUPPLEMENT* of January 29, 1943, indicates that chemical treatment of seed offers little hope for increasing crop yields. Although the following context of the item makes it sufficiently clear to those familiar with the various types and purposes of seed treatment that treatment with growth-regulatory substances is in question, this item and others constantly appearing in the press indicate the need for more explicit reference to seed treatment if an important wartime contribution of science is not to suffer.

Several types of chemical seed treatments with several purposes are in common use or experimental stages to-day. Seeds may be treated with disinfectant chemicals to rid their surfaces of the organisms of disease and furnish chemical protection against such organisms in the soil; they may be treated with corrosive chemicals to alter the permeability of the seed coats and facilitate germination, a common practice in tree propagation; they may be treated with rodent-repelling chemicals as kerosene, turpentine or creosote; they may be chemically treated in the very doubtful, but commercially exploited, hope of thus imparting insect resistance to the resulting plants; they may be treated with growth-promoting substances in the expectation of thus increasing growth and yields; and leguminous seed are commonly treated with dusts con-

taining nodule bacteria for increasing nitrogen fixation. It is important that these types of treatment be clearly differentiated in publicity.

Disinfectant seed treatments are of well-established value in the production of many crops and represent one of the most useful devices for increasing wartime production. It would indeed be unfortunate if the efforts of crop scientists and agricultural extension specialists to promote further adoption of them were to be thwarted by public statements, however correct, that chemical seed treatments (of certain other types) are useless or harmful.

K. STARR CHESTER

OKLAHOMA AGRICULTURAL AND
MECHANICAL COLLEGE

MINERAL DEPOSITS

MAY I make a suggestion that, if followed, may prove extremely valuable to our country and at the same time increase the contributions made by science to the war effort?

Vast quantities of ores and minerals are necessary to carry on the war. Commercial development after we win this war will likewise require mineral products in quantities that we may find difficult to supply.

Men in the Armed Forces will probably travel very nearly all over the world before the present war is finished. Would it not be wise, therefore, to give all officers of the Army and Marine Corps a short but intensive course in the recognition or identification of the ores of the more important metals. Thus equipped, they would constitute searching parties or prospectors, some of whom certainly might discover mineral deposits that would prove valuable or even vital to our cause. If all members of our Army and Marine Corps who will be going afield could be given this training, instead of just the officers, it should obviously increase our chances of finding these much-needed minerals.

Colleges and universities that teach geology, mineralogy, etc., could give such training, as could most commercial geologists and others who are familiar with rocks and minerals. If it is not practicable to give this training at the colleges and universities, then training centers manned by competent instructors could be set up in connection with already established Army and Marine Corps camps.

J. J. WOLFORD

MIAMI UNIVERSITY, OHIO

QUOTATIONS

THE RETIREMENT OF PROFESSOR RAYMOND C. ARCHIBALD

Few scholars have a larger circle of personal friends

among mathematicians on both sides of the Atlantic than Professor Raymond C. Archibald, whose impending retirement is announced from Brown Uni-

versity. An official position in the American Mathematical Society has brought him into touch with every active mathematician of this century in America, while in the course of frequent and extensive journeys in Europe to ransack bookshops and visit libraries, he has taken every opportunity to make the acquaintance in their own countries of the men and women whose writings he already knew. Enthusiastic, persuasive and learned, he has made the mathematical section of the library at Brown University one of the finest to be found anywhere, and he has created there for mathematicians the surest source of bibliographical and biographical information in the world.

Professor Archibald's published works include the definitive edition of one of Euclid's minor treatises, and the semi-centennial history of the American Mathematical Society, the latter a heavily documented volume incorporating twenty-seven biographical sketches. He is the author of a vast number of bibliographical articles, distinguished for an impersonal and uncritical thoroughness that conceals the toil and the knowledge that go to their compilation, and is, it must be confessed, sometimes carried to excess, for Archibald's modesty will not allow him

to believe that if only, like Keynes and Muir, he would sometimes tell us after reading a paper that no one need ever read it again, others would gladly accept his judgment and be spared the tedium of making the discovery for themselves. Professor Archibald has served for long periods on a number of editorial boards, and is now editing for the National Research Council of the United States the youngest of mathematical journals, *Mathematical Tables and Aids to Computation*. To Professor Archibald, retirement will not spell indolence. It need scarcely be said that his expert advice will still be available in the library which he has made famous, he is continuing in his latest editorship, and he hopes to devote the time saved from routine to perfecting the organization of a library of English and American poetry and drama which he has been developing at Sackville since 1905 in memory of his mother. Increased leisure, if miraculously he achieves it, will mean enhanced opportunities to cultivate a second passion, for he is not merely a lover of music but also a musician of exceptional skill, who might easily have become a professional violinist and remained an amateur in mathematics. May he long enjoy a strenuous life.—*Nature*.

SCIENTIFIC BOOKS

THE BLOOD IN TUBERCULOSIS

Clinical Significance of the Blood in Tuberculosis.

By GULLI LINDH MULLER. Pp. xvii + 516. The Commonwealth Fund. 1943. \$3.50.

SINCE medical monographs assume places of authority in medical knowledge they should meet two requirements. First, the scattered literature on a subject should be concisely and completely presented. Dr. Muller has performed a commendable and difficult task in this phase of her book, although citations and bibliography are not complete. Second, the observations of the author should be presented in such fashion that the reader can easily grasp the full significance of the data presented. In some instances Dr. Muller has failed to fulfil this requirement.

The emphasis placed upon *qualitative* changes in neutrophiles when the author states "the omission of shift in the neutrophiles in the description of a leukocytic picture is a gross error comparable to an examination of the heart without counting the pulse" is a case in point. Discussion of the data presented in the table on page 57 emphasizes that "shifts to the left" are commonly present in normal leukocytic counts (author's standard). Hematologists would agree that a percentage of 8 or more "band forms" is beyond normal limits. As I reported in the *American Journal of Medical Sciences* in January, 1929, the upper nor-

mal limit of neutrophiles is 65 per cent. Dr. Muller presents no data, either from her own studies or from the literature, to refute the reliability of my data. On the basis that above 65 per cent. of neutrophiles is abnormal, the table on page 57 shows that two thirds of the counts are abnormal and one third normal. In the abnormal range 46.5 per cent., and in the normal range 15 per cent., reveal an increase of "band forms." As the percentage of neutrophiles increases, especially above normal, the percentage of "shift to the left" increases. Without minimizing the significance of qualitative changes one may question the wisdom of insisting that Schilling counts be done on all leukocytic counts. A better policy would be to let the hematologist decide when Schilling counts are essential. Careful thought must be given to the diversity and quantity of laboratory tests recommended for a routine diagnostic service.

The rather lengthy dissertation on the eosinophile seems to be out of place since Dr. Muller states "eosinophilia . . . may anticipate an *improvement* or a *deterioration*," i.e., no definite interpretation can be given an eosinophilia *per se*. The suggestion that eosinophilia in tuberculous cases reflects "an allergic response" hardly seems valid, since only 20 per cent. of the cases exhibited an eosinophilia and probably the entire group would react to tuberculin.

Since hematologists agree that the percentage distribution of the different cell types is of paramount importance in leukocytic counts it would seem that the contents of Chapters 9 and 10 could be condensed to advantage. It is regrettable that Dr. Muller has not stressed the fact that a leukocytic count contains at least six variables and that it is the proportional relationship of the variables that constitutes the significance of any leukocytic count.

The chart shown on page 163 presents an interesting theoretical concept. It can not be accepted as factual for two reasons—first, it is extremely difficult to determine when a tuberculous individual has eradicated the tubercle bacillus from his system; second, to assume that a tuberculous infection may be "healed" because leukocytic counts remain within normal limits is unwarranted.

The occurrence of anemia in tuberculous patients is generally recognized and the need to determine the type of anemia is evident. Dr. Muller's presentation of this subject is valuable. A condensation of the text would enhance its value.

The sixty-page dissertation on the sedimentation rate of erythrocytes could be condensed considerably, thus emphasizing the salient facts. The correction table devised by Dr. Muller undoubtedly permits a more precise determination of the "rate of sedimentation." From a practical point of view the necessity for such precision may be debated. To the clinician the thing of importance is whether the rate is abnormal and, if so, how far it deviates from normal. In this respect the results should not be interpreted too finely—a difference of 0.5 mm per minute would be significant, whereas a difference of 0.2 mm would be equivocal. In a routine diagnostic service a single reading at one hour and a determination of the percentage of sedimentation based upon the plasma volume will give the clinician the essential facts, although admittedly this method does not guarantee the mathematical accuracy of Dr. Muller's method. Dr. Muller might have added to her requirements a uniform temperature for all sedimentation tests since temperature does affect the test to some extent.

In Part 4 Dr. Muller demonstrates that hematological and clinical findings often disagree, especially in individuals who seem to be progressing satisfactorily. It is where such disagreements occur that the hematological findings are of especial value. That

the leukocytic reaction and the sedimentation rate are two independent phenomena which often disagree is also clearly demonstrated. This portion of the monograph would be improved greatly by a reduction in the number of tables and graphs. In some instances the number of patients and of serial tests is too small to carry much weight.

On page 311 Dr. Muller states: "The index is unfavorable in 37.8 per cent. of the examinations in Group A; as seen above these cases were clinically quiescent most of the time. Since there is an incidence of lymphopenia in only 14.1 per cent., and of neutrophilia in only 7.4 per cent., the unfavorable index is obtained by the interpretation of essentially normal values." This interpretation is based upon the arbitrary normal values proposed by Dr. Muller, not upon the normal values which I reported in the *American Journal of Medical Sciences* in January, 1929. It is impossible to obtain an unfavorable index from normal leukocytic counts if the normal values I have determined are used. Furthermore, unless such normal values are acceptable the index values are not valid.

The reviewer is impressed by the fact that Dr. Muller considers changes within a rather narrow zone in Schilling counts and in sedimentation rates as significant, whereas rather broad changes must be present in a differential percentage before any interpretation is allowed. This is a common error among physicians and is due apparently to the difficulty of appreciating proportional changes between several variables. The entire purpose of the leukocytic index, as reported by the reviewer, was to demonstrate that proportionally the several variables could be abnormal in a leukocytic count that would ordinarily be accepted as normal.

Part 6 is well done. Dr. Muller could have insisted, with profit, on the counting of 400 cells to obtain a differential percentage to make the determination reliable statistically when different counts are to be compared. A reliable count can be obtained from a single well-made blood smear.

The general impression of the reviewer is that a much more concise monograph on this important subject would have evolved had the author had a much longer and broader experience in the field of tuberculosis.

E. M. MEDLAR

SPECIAL ARTICLES

AN EXPERIMENTAL TEST OF THE FRAMEWORK THEORY OF ANTIGEN-ANTIBODY PRECIPITATION

THE framework theory (lattice theory) of sero-

logical precipitation and agglutination, first proposed by Marrack,¹ has not been accepted by all investiga-

¹ J. R. Marrack, "The Chemistry of Antigens and Antibodies," Report No. 194 of the Medical Research Council,

tors in the field, although it is supported more or less strongly by a considerable body of evidence.^{1,2,3,4} We have now carried out some experiments which correspond so well in their results with the predictions of this theory as to leave little doubt of its correctness.

We have synthesized a substance which gives a specific precipitate with a mixture of two different antisera, but gives no precipitate with either antiserum alone. The substance contains two different haptenic groups, R and X, to which the two antisera are homologous: the anti-R serum was made by injecting rabbits with azoprotein containing R groups, and the anti-X serum by injecting with azoprotein containing X groups. The R and X groups were respectively the *p*-azophenylarsonic acid group and the *p*-azobenzoic acid group, and the RX substance used in most of our work was 1-amino-2-*p*-(*p*-azophenylazo)phenylarsonic acid-3,6-disulfonic acid-7-*p*-(*p*-azophenylazo)benzoic acid-8-hydroxynaphthalene. Similar results were also obtained with 1,8-dihydroxy-2-*p*-azophenylarsonic acid-3,6-disulfonic acid-7-*p*-(*p*-azophenylazo)benzoic acid-naphthalene.

The experimental results show that in the formation of the precipitate both of the two haptenic groups of the molecule enter into specific reaction, the R group with an anti-R antibody molecule and the X group with an anti-X antibody molecule. This is shown by the fact that the RX substance precipitates only with a mixture of the two antisera, and not with either one alone; the explanation of the failure of precipitation with only one antiserum given by the framework theory is that with respect to either antiserum the RX molecule is only monohaptenic and hence only univalent, and so can not act as the link between antibody molecules in the formation of a framework.

With the effective bivalence of the precipitating antigen thus proved, knowledge of the antibody-antigen molecular ratio for the precipitate provides the value of the average valence of the antibody molecules. The molecular ratio was found by analysis to be 0.7, which corresponds to $2/0.7 = 2.8$ for the average antibody valence.⁵ If the antibody were univalent the molecular ratio would have the value 2, which is far greater than the experimental value. Further evi-

dence for the effective multivalence of antibody is provided by the observation that the RX precipitate is soluble in excess of the mixed antisera; this solubility can not be explained on the basis of univalent antibody.

A detailed account of this work will be published in the *Journal of the American Chemical Society*.

LINUS PAULING
DAVID PRESSMAN
DAN H. CAMPBELL

GATES AND CRELLIN LABORATORIES OF
CHEMISTRY,
CALIFORNIA INSTITUTE OF TECHNOLOGY

THE PRODUCTION OF MULTIPOLAR MITOSES IN NORMAL EMBRYONIC CHICK CELLS

THE sporadic occurrence of an abnormal type of cell division, namely, multipolar mitosis, in normal somatic cells remains unexplained. Kemp¹ reported finding a single tripolar mitosis in approximately 10,000 dividing cells in tissue cultures of tissues from normal chick embryos and adult fowls. A later study² of dividing cells from a double monster (*Cephalopagus*) revealed five triasters among 500 mitotic cells. The fact that multipolar mitoses with resultant unbalance of chromosome number in daughter cells occur during the growth of certain types of malignant cells is too well known to be emphasized.^{3, 4, 5, 6} However, the significance of their occurrence in relation to malignancy has not yet been established. Attempts to produce this type of cell abnormality in normal somatic cells have met with varied degrees of success.^{7, 8, 9, 10}

In the present experiments 4 series of cultures (total 92) of eight-day normal embryonic chick heart muscle were made by the usual hanging drop technique. A total of 12 to 14 chick hearts were used. The culture medium consisted of 1 drop of fowl plasma (dil. 1:1 with Tyrode solution) and 2 drops of a mixture of embryonic juice from 8- and 11-day chick embryos (dil. 1:1 with Tyrode solution). The

¹ T. Kemp, *Zeit. f. Zellforsch. u. mikrosk. Anat.*, 11: 429, 1930.

² T. Kemp and J. Engelbreth-Holm, *Arch. f. exp. Zellforsch.*, 10: 117, 1931.

³ Th. Boveri, "Zur Frage der Entstehung der malignen Tumoren." Jena, 1914.

⁴ M. Levine, *Jour. Cancer Research*, 14: 400, 1931.

⁵ M. R. Lewis and L. C. Strong, *Am. Jour. of Cancer*, 20: 72, 1934.

⁶ J. Maurer, *Arch. f. exp. Zellforsch.*, 21: 191, 1938.

⁷ W. G. Whitman, *Am. Jour. of Cancer*, 17: 932, 1933.

⁸ E. Marie Hearne Creech, *Am. Jour. of Cancer*, 35: 191, 1939.

⁹ W. R. Earle and Carl Voegtlin, *Public Health Reports*, 55: 303, 1940.

¹⁰ E. F. Stilwell, *Anat. Rec.*, 76: 205, 1940, and 84: 193, 1942.

His Majesty's Stationery Office, London, 1934; Second Edition, Report No. 230, 1938.

² M. Heidelberger and F. E. Kendall, *Jour. Exptl. Med.*, 61: 559, 563, 1935; 62: 467, 697, 1935; M. Heidelberger, *Chem. Rev.*, 24: 323, 1939.

³ L. Pauling, *Jour. Am. Chem. Soc.*, 62: 2643, 1940.

⁴ L. Pauling, David Pressman, Dan H. Campbell and collaborators, *ibid.*, 64: 2994, 3003, 3010, 3015, 1942; 65: 728, 1943.

⁵ Similar values of the antibody-antigen molecular ratio have been previously reported (footnote 4) for precipitates of anti-R antisera and simple substances containing two or more R haptenic groups.

medium was renewed on the cultures of series 1 and 2 on the sixth day of cultivation; on those of series 3 and 4 on the seventh day. Cultures of series 1 and 2 were fixed for cytological study on the seventh day of life *in vitro*; those of series 3 and 4 on the eighth day. The temperature for incubation was constant at a given point in the incubator but varied from 42+° C. at the back side to 37½° C. at the front. The heating units of the incubator consisted of two electric light bulbs (carbon). Consequently, light of a very low intensity was emitted intermittently. All cultures placed in the back half of the incubator were killed.

Microscopic examination of cultures of series 1 revealed the presence of numerous multipolar mitoses (chiefly triasters) in 8 of the 12 cultures fixed and stained. In cultures of series 2, 3 and 4 frequent triasters and other aberrant forms of mitosis have been found in at least 2 cultures of each series. The abnormal division figures consist chiefly of: triasters (ana-, telo-, and reconstruction phases); cells with 3 poles and two spindles. "Resting" cells with two or more nuclei are of frequent occurrence; chromosome vesicles (16 in one cell) have been observed. The unusually large size of cells exhibiting these abnormalities is noteworthy. The cultures presented a very vigorous growth. Over 500 dividing cells were counted in culture 2 of series 1.

A detailed study of the cultures at hand is in progress and the results will be published elsewhere at a later time. From the results already obtained it is obvious that the possibility of repeated production of multipolar mitoses in normal somatic cells *in vitro* is an important point of departure for determining the significance of this phenomenon of cell growth in relation to malignancy. A program of experimental work designed to analyze the factors responsible for the production of these modified cells has been planned.

E. FRANCES STILWELL

DEPARTMENT OF ANATOMY,

WOMAN'S MEDICAL COLLEGE OF PENNSYLVANIA

THE ROLE OF NIGHT TEMPERATURE IN PLANT PERFORMANCE¹

In the course of observations of the responses of some 240 varieties or species of plants to different temperatures and photoperiods² chance evidences became increasingly suggestive that the temperature during the night rather than the daytime level largely determines the type of response which the plants make to temperature. Hamner and Bonner³ have

reported this is true in the case of *Xanthium* (cocklebur).

This past winter several species of plants were grown in four greenhouses at different temperatures, approximately as follows: cool (55° F.); cool/warm (55° F. at night and 75° F. in the daytime); warm/cool (75° F. and 55° F.); and warm (75° F.). Each house had provision for both long- and short-day treatments. Some of the reactions of the plants given warm nights and cool days will be reported briefly.

They were of a pale color, particularly those in short days. "Warm climate" plants as Proso millet, corn, hemp, Biloxi soybean and sorghum were particularly yellowish, some being near the color "Grapefruit."⁴ "Cool climate" plants as oxeye daisy, timothy, rye, nasturtium, brome grass and blue grass, on the other hand, developed a relatively good green color in cool days following warm nights.

The plants with pale color because of cool days following warm nights made relatively little growth when compared to those with warm days, either with warm or cool nights. They did, however, have practically normal blossom induction reactions. This was true for such short-day plants as Biloxi soybean, hemp, pigweed, cocklebur, poinsettia, Refugee bean and Jimson weed as well as the long-day species alfalfa, beet and snapdragon. Indeterminate types, as tomato, Russian dandelion and Alaska pea, had a time schedule like the plants in the warm house.

The warm nights with cool days had an effect like the continuously warm environment of delaying or inhibiting the flowering of snapdragon, poinsettia and beets. Other effects which were comparable in these two temperature environments were a reduction in the setting of seed of Alaska peas, alfalfa and yellow sweet clover, delayed tuberization of potatoes, reduced root formation by Russian dandelions and a masking of potato virus symptoms.

Some cool temperature plants, as bluegrass, oats and barley, tend to head better in the cool-day house with warm nights than when these are kept warm both day and night, but do not set seed well as in the cooler houses. It would appear possible to use such types and secure evidence that the daytime temperature is most important. Such a conclusion should await the results from carrying the day temperatures at a lower level than was used this season.

These limited preliminary observations indicate that for a number of plants at least, the temperature during the dark period of the day is an important factor affecting blossom induction as well as some other reactions.

R. H. ROBERTS

DEPARTMENT OF HORTICULTURE,

UNIVERSITY OF WISCONSIN

⁴ A. Maerz and Paul M. Rea, "A Dictionary of Color." New York: McGraw Hill.

¹ Published with the approval of the director of the Agricultural Experiment Station.

² R. H. Roberts and B. Esther Struckmeyer, *Jour. Agr. Res.*, 56: 633-677, 1938; *ibid.*, 59: 699-710, 1939.

³ Karl C. Hamner and James Bonner, *Bot. Gaz.*, 100: 388-431, 1938.

SCIENTIFIC APPARATUS AND LABORATORY METHODS

MICROBIOLOGICAL DETERMINATION OF AMINO ACIDS

THE authors have found that microbiological techniques similar to those used for vitamin assays can also be used for rapid and accurate determinations of amino acids. *Lactobacillus arabinosus* 17-5 appeared to be the most satisfactory of a large number of organisms tested. The following amino acids were found to be essential for the growth of this organism: glutamic acid, tryptophane, threonine, valine, leucine, isoleucine, cystine, lysine and phenylalanine.

In addition, alanine, arginine, aspartic acid, histidine, proline, serine, methionine and tyrosine increased the growth of the cultures and hence were included in the medium.

When *p*-aminobenzoic acid was added to the Snell and Wright¹ assay medium for nicotinic acid, a mixture of the above amino acids was found to adequately replace hydrolyzed casein. The growth of the bacteria on the synthetic medium was further increased by a concentrate prepared from tomato juice as described below. This concentrate appears to contain an unknown growth-stimulating factor for *Lactobacillus arabinosus*.

The active material was adsorbed from clarified tomato juice with Norite A at pH 3. Elution was effected with a pyridine, ethanol, water mixture (in the ratios 1:2:1). The eluate was evaporated to dryness and the residue hydrolyzed with 8N H₂SO₄. After removing the H₂SO₄ with Ba(OH)₂ the adsorption and elution was repeated.

The complete medium as used for the determination of the amino acids is based on that of Snell and Wright¹ with the casein hydrolyzate replaced by 2 milligrams of each of the above-mentioned amino acids (except glutamic and aspartic acid, which were used at a 4 mg level) and 1 mg of Norite eluate per 10 ml of completed medium. Para aminobenzoic acid was also added to the medium.

By leaving out one of the amino acids which is essential for the growth of *Lactobacillus arabinosus*, a medium for the determination of that particular amino acid is prepared. The method of conducting the tests is essentially the same as is used for the determination of nicotinic acid, titration of the amount of lactic acid formed in the test cultures being indicative of the amount of the amino acid which is present in the unknown.

The authors have found the method particularly useful for the determination of valine, leucine and isoleucine. These amino acids are sharply differentiated biologically, although their chemical structures

¹ E. E. Snell and L. D. Wright, *Jour. Biol. Chem.*, 139: 675, 1941.

are so similar that accurate determination by chemical means is difficult.

Pure samples of these three amino acids are more readily obtainable as the synthetic *dl* forms. In the case of valine and leucine only the naturally occurring *l* forms are active, the *d* forms being completely inactive. The *dl* forms may be used as standards, two weight units of the *dl* form being exactly equivalent in activity to one unit of the pure *l* form. Standard curves for valine determinations cover the range from 0 to 0.08 mg of *dl* valine. For leucine the range is from 0 to 0.16 mg of the *dl* form. Synthetic *dl* isoleucine can probably be used as a standard as soon as studies concerning the specificity of the bacteria for the four forms of this amino acid are complete.

TABLE I

SPECIFICITY OF *Lactobacillus arabinosus* FOR THE OPTICAL ISOMERS OF SOME AMINO ACIDS

Amino acid	Optical form	Weight per test	Titration values,*	
		mg	0.1 N NaOH	
			ml	
Valine	0.00	0.56	0.54
Valine	d(-)	0.02	0.52	0.54
Valine	l(+)	0.02	2.17	2.19
Valine	dl	0.04	2.19	2.19
Leucine	l(-)	0.04	2.70	2.82
Leucine	dl	0.08	2.85	2.82
Glutamic Acid	l(+)	0.02	2.78	2.82
Glutamic Acid	dl	0.04	2.78	2.82
Lysine	l(+)	0.04	2.82	2.79
Lysine	dl	0.08	2.76	2.79

* 5 ml aliquots from 10 cc culture tubes.

Table I shows the specificity of *Lactobacillus arabinosus* for the optical isomers of some of the amino acids.

A detailed report covering the application of the method to the determination of amino acids in protein hydrolyzates will be published elsewhere in the near future.

K. A. KUIKEN
WILLIAM H. NORMAN
CARL M. LYMAN
FRED HALE

TEXAS AGRICULTURAL EXPERIMENT STATION,
A. AND M. COLLEGE OF TEXAS

BOOKS RECEIVED

- DAVIS, A. F. and POWERS, ED. C. *Studies in Arc Welding*. Illustrated. Pp. xxxi + 1295. James F. Lincoln Arc Welding Foundation, Cleveland, Ohio. \$1.50.
FULTON, JOHN FARQUHAR. *Physiology of the Nervous System*. Illustrated. Pp. ix + 614. Oxford University Press. \$9.00.
WAHLSTROM, ERNEST E. *Optical Crystallography*. Illustrated. Pp. v + 206. John E. Wiley and Sons. \$3.00.
WOOD, CASEY A. and F. MARJORIE FYFE. *The Art of Falconry*. Illustrated. Pp. cx + 637. Stanford University Press. \$10.00.